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Contributed paper

Large offset monochromators at PETRA III

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For the beamlines of the new synchrotron radiation source PETRA III, fixed-exit double crystal monochromators with specific features were developed. To achieve a compact arrangement of the canted undulator beamlines at Sectors 2, 4 and 6, it is necessary to shift one of the two beamlines in vertical direction. This is done by so-called large offset monochromators. Two of these monochromators (LOM500 and Mono-P06) accept the white beam and are therefore cooled with liquid nitrogen. The third one accepts a monochromatic beam and has no cooling system. The challenge with this device (LOM1250) is the large offset of the beam by 1.25 m. The energy range in combination with the large vertical beam offset demands for a relative crystal movement of roughly 3 m along the beam direction. This is implemented by translating each crystal by up to 1.5 m. It is equipped with a visible laser-based stabilization which allows compensating thermal drift of the mechanical components involved in the positioning of the crystals. With this novel approach the X-ray beam is not attenuated by beam position monitors.

1. Purpose and requirements

The main purpose of the large offset monochromators LOM500 and LOM1250 is to separate the two beams coming from a canted undulator setup. This is done by a vertical shift of the beam by 500 and 1250 mm, respectively. The Mono-P06 shifts the white beam only by 21 mm upwards. Because of the long travel of the linear stage of the Mono-P06 and the need for cryocooling it is built up by components similar to the LOM500.

2. Common design and common mechanical components of the large offset monochromators

The cryostats used for LOM500 and Mono-P06 are of the same type as for the generic high heat load monochromators. This simplifies the maintenance and usability of the installations. Further the wire rope guide of the liquid nitrogen hoses for LOM500 and Mono-P06 is built with identical components. The

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translations and goniometers are of similar type so that the same control concept and hardware can be used for all three monochromators. All systems are equipped with the same kind of piezo stage which allows one to adjust the optics in height, pitch and roll.

3. LOM500

This monochromator (see figure 1) can be used with a Si 111 pair (8–25 keV) and a multilayer pair (8.4–11.5 keV for 20 Å spacing). Two plane mirrors are provided behind the LOM500 for higher-order suppression. When bypassing the mirrors the offset of the monochromator is set to 500 mm downwards, when using the mirrors the offset is set to 490 mm. All optical components are cryocooled. The second crystal or multilayer is mounted on a 2.5 m linear translation.

4. LOM1250

The energy range for the Si 311 is 5.4–18.8 and 8.4–29.4 keV for the Si 511 crystal pairs (Horbach *et al.* 2010). These can be changed by a lateral drive. This monochromator (see figure 2) is equipped with additional monitors to measure the position of the laser beam (Degenhardt *et al.* 2010). This is done with a transparent screen with a reticle behind the first crystal and by two charge coupled device (CCD) monitors behind the second crystal (see figure 3). With this setup one can determine the deviations of the first crystal in pitch and roll and of the second crystal in pitch, roll and height separately. Using this information, these deviations are compensated by the piezo stages with three dimensions of freedom each. Besides this there are two beam position monitors (detection of back-scattered light emitted from a metal foil with four pin diodes) for the X-ray beam behind the second crystal and a metal foil behind the first crystal (measuring of the photo current). Without any stabilization the X-ray beam is stable within approximately ±0.26 μrad measured at the end station of the beamline at 9 keV. The laser stabilization of the beam position at the experiment enables a control of pitch and roll with a standard deviation

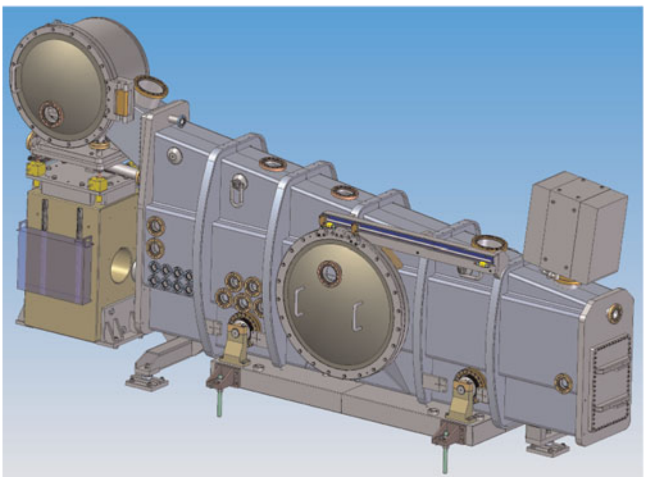

FIGURE 1. CAD-model of LOM500, system is installed at P03.

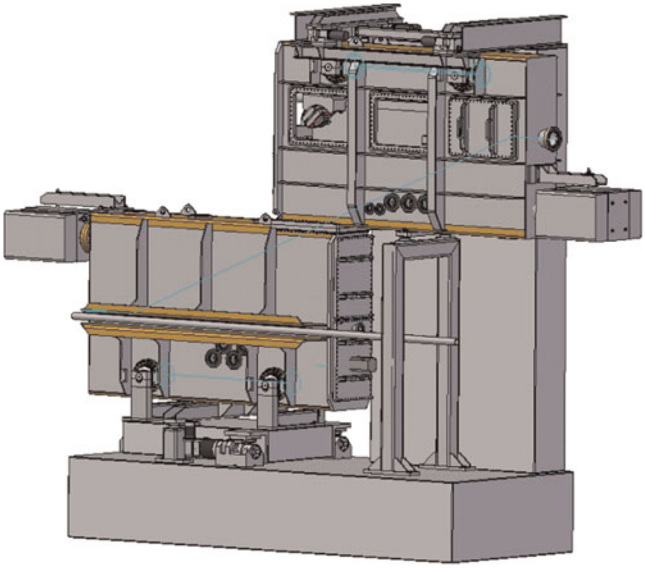

FIGURE 2. CAD-model of LOM1250, system is installed at P08.

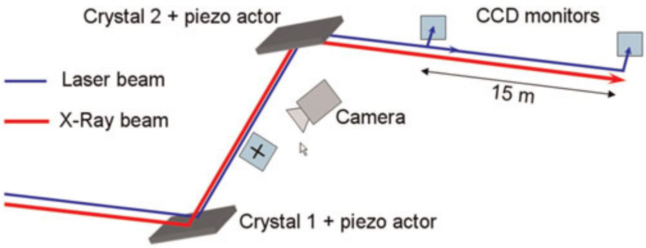

FIGURE 3. Principle of the LOM1250 laser stabilization system.

smaller than ±0.25 μrad for the position of the laser spot at the experiment. One has to consider that the measured positions at the three monitors are used for the calculation of the positions of five piezo actors (the height of the first piezo stage is not used as this degree of freedom is not observable in this setup). If only the pitch piezo of the second crystal is used for stabilization the standard deviation of the laser spot position at the end station decreases to ±0.05 μrad (equal to ±0.75 μm). In this mode of operation an error in height could be mistaken for an error in pitch and could lead to a mistuned crystal. Special care has to be taken concerning the thermal stability in the optics hutch. The support of the laser incoupling is sensitive for changes in temperature, which pretends a change in crystal position. This would lead to a mistuned crystal and loss of intensity at the experiment. A granite socket should be used for the laser incoupling and the temperature should be stable within ±0.1°C.

5. Mono-P06

The multilayer monochromator at beamline P06 (see figure 4) has a large energy range of 4.4–90 keV. Therefore, it is equipped with a long linear translation of 3.9 m.

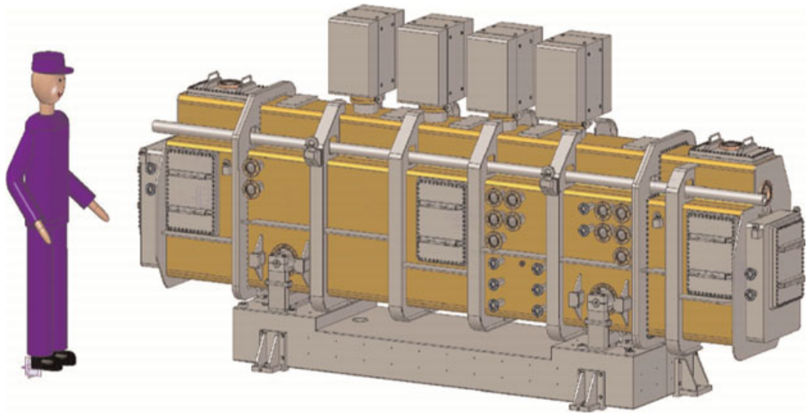

FIGURE 4. CAD-model of Mono-P06.

The offset is relatively small (21 mm). The experience gained at the LOM500 and LOM1250 influenced the design of this monochromator. As this monochromator accepts the white beam both crystals have to be cryocooled. The supply of the moving crystal with liquid nitrogen is challenging as the reliable handling of the hoses has to be ensured and cold gaps have to be prevented.

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